

SRB Altitude Switch Assembly Wire Harness Failure

The following report was written directly by Mr. Jim Blanche and submitted to Anthony Williams also of bd Systems at the conclusion of this task. It serves as the summary report of the failure assessment and MRB rationale.

Memo:

To: Tony Williams

From: Jim Blanche

Date: 11/27/02

Re: SRB Altitude Switch Assembly Wire Harness Failure

On November 5-7, 2002, I traveled to CMC Electronics, Cincinnati, Ohio, with Kendall Junan/MP41 and Robert Fowler/HEI, to assess two wire harness failures that had occurred in Solid Rocket Booster Altitude Switch Assemblies S/N 200001 and S/N 200002.

While in Cincinnati we worked with CMCE personnel: Jim Tepe, Project; Steve Jacobs, Engineering; and Rick Roelecke, Quality Assurance; and USA personnel: Mark Ross, Project; George Casas, Engineering; Tim Denny, Dynamics; and Sylvester Brown, Quality Assurance.

The ASA design contains an EMI filter cavity and the pressure sensor with its associated A/D circuit board hard mounted in the housing, and a two board module which is tied to a pivot point on the inside of the housing and rotates into place at assembly. The wire harnesses interconnect the module to the switch board and to external connectors in the housing. The harnesses require service loops to be able to rotate the module. The wires are soldered to the connector pins, and heat shrink sleeving is put over these joints. The harnesses are spot tied over their length.

The chafed wire problem in ASA S/N 200001 was the result of a stiff harness service loop rubbing against the chamfered corner of a boss in the housing during vibration. The insulation rubbed through to expose the wire, and the wire shorted to the housing. The problem in S/N 200002 was a broken wire (P2-16) on the test connector. It was found while inspecting this unit for harness chafing. This harness is not monitored during vibration so it is not known when the break occurred. Further inspection of the P2 connector harness showed another wire (P2-2) broken within the insulation sleeving and other wires with broken strands. S/N 200001 was reinspected and no broken wires were found but several wires showed birdcaging. CMCE clipped the end of the broken P2-16 wire for further evaluation. Their failure report states that the evaluation showed a

combination of sheared and elongated wire strands. This is a questionable conclusion. The assumption is that the wires failed as a result of high cycle fatigue during vibration, not from shear or tensile loading. I asked if CMCE had a metallurgist look at the broken wires and was told they had not. I requested that this be done so they could verify that the failure was a high cycle fatigue failure and to see if the failure may have been initiated by bending stresses on the wire from flexure during assembly and troubleshooting. They agreed to do this but it is not presently identified on the Action Plan.

The insulation sleeving on the termination of the wires to the connector was MIL-I-23053/08 shrink sleeving which did not grip the wire and connector pin tightly after shrinking. The other harnesses used a /05 sleeving which did grip the wire and pin tightly. We looked at the two qualification units and an engineering development unit that were on the shop floor. In addition to looking at the wire harnesses I also looked at the overall packaging and circuit board design as requested by David Martin. The design of the circuit boards looks good and the packaging into the box does not show any obvious packaging issues. Had I been part of the design review of the Altitude Switch Assembly I would not have flagged the wire harnesses as a potential problem.

Several design fixes to both the chafing and wire fatigue problems were proposed. It was proposed that the box bosses be rounded on the flight boxes and that Dielectric Polymers, Inc. NT-580 Platers Tape be put onto the bosses on the inside of the box as insulation. Newark 50N478 Voltrex Flame Retardant Expandable Fray-Resistant Sleeving would be used on all wire harnesses in lieu of spot tying. This would both insulate the harnesses and make them more flexible. To assure that the wire/pin connections could not move under vibration, it was suggested that a flat epoxy-glass board be bonded to each connector extending downward so the harness wires could be spread and bonded to the board with 3M Scotch-Weld Epoxy Adhesive 2216 B/A Tan NS. This is the same epoxy that is already used in the box to bond wires to other boards. A quick sample of this approach was put together but some bonding difficulties were encountered between the glass-epoxy and the AirBorn connector body which is glass-filled polyphenylenesulfide. Another approach to secure the wire terminations from vibration damage was to pot the back of the AirBorn connectors. Quick samples of this approach were also made to look for any bonding problems. One sample was made using the Scotch-Weld 2216 and one was made using Stycast 2850. Both materials appeared to bond well to the connector body.

It was recommended that the wires on the other end of the J-2 harness that terminate in the circular box connector be supported with an RTV silicone for additional strain relief so that they will not be subject to vibration failure. It was also suggested that Poron, which is the sponge rubber material bonded to the inside bottom of the box, be built up on the J-2 side of the box next to the Sensor A/D circuit board to prevent contact between the harness and the board during vibration.

There was some concern expressed by CMCE and USA that the qualification unit might be exposed to excessive qualification level vibration so it was recommended that the modifications be made first to one of the development units and that unit exposed to full

vibration qualification level and duration. This would serve to give confidence in the effectiveness of the fix and would also give the shop an opportunity to practice and refine the modification procedure on a piece of non-flight hardware. We were assured by USA that no hardware modification would be done until a procedure had been documented. As a result of this trip and a telcon held on November 8 with SRB Project Office, CMCE and USA the following action plan was generated on November 12, by USA for the ASA modification:

Modifications to EDU #4 for new harness design verification

1. Install overall expandable cable jacket sleeving P/N 50N-478 on the three harnesses
2. Re-terminate and install /05 sleeving on the three AirBorn connector contacts.
3. Pot the three AirBorn electrical connectors (option1)
4. Add RTV to the backside of the external J2 connector (additional strain relief)
5. Install insulation tape P/N NT-580 on housing bosses that can contact harnesses
6. Install Poron barrier adjacent to Sensor A/D circuit board, J2 connector side of box
7. Perform 3 axes Ascent and Re-entry vibration tests on units
8. Perform abbreviated functional test
9. Open unit and perform visual inspection of harnesses

Modification Of Qualification Units 2000001 and 2000002

Qualification units.

1. Qualification units will be visually inspected with anomalous conditions photographed and documented prior to rework/repair.
2. All hardware modifications and processes will be submitted to USA on redlined drawings prior to performing rework/repair to be part of the PR closure report
3. Install Poron barrier adjacent to Sensor A/D sensor circuit board, J2 connector side of box
4. Install insulation tape P/N NT-580 on housing bosses that can contact harnesses
5. Install overall expandable cable jacket sleeving P/N 50N-478 on the three harnesses
6. Re-terminate and install /05 sleeving on the three AirBorn connector contacts
7. After confirmation of connector potting acceptability, pot all 3 AirBorn electrical connectors
8. Add RTV to the backside of the external J2 connector (additional strain relief)
9. Seal unit and perform fine and gross leak check.
10. Perform functional test of test connector. (Check for proper outputs)
11. Perform four operational thermal cycles on units per QTP section 3.5.4 with testing performed at the first and fourth cycle per figure 3.5.4.2
12. Continue with qualification testing per QTP section 3.5.9
13. At the completion of qualification testing perform 20 mission Ascent and Re-entry vibration tests per QTP section 3.5.7 and 3.5.8
14. Perform tear down inspection per QTP655800 section 3.5.17 and 10SPC-0242 section 4.2.4.2

Note: Modification sequence is subject to change to improve efficiency. Modifications to EDU #4 and qualification units are identical. The qualification units and production unit are identical with the exception of the MIL-DTL-23053/08 sleeving on the external flight connectors.